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desirable that another solution be presented. Professor Carmichael called my attention to this error.

As a solution by Calculus would be very long and tedious and well nigh impossible, we will use a formula given in the *Encyclopædia Britannica*. It is as follows:

If p is the probability of a certain condition being fulfilled by n points within an area A , p' the probability when they fall on area $A+B$ (B without A), p_1 the probability when one point falls on B and the rest on A , then $(p'-p)A=nB(p_1-p)$.

In the problem, $A=\pi a^2$, $B=(4-\pi)a^2$, $n=2$, where $2a$ =side of the square. Now $p'=\pi-\frac{1}{8}$ (MONTHLY, Vol. III, No. 11, page 285); $p=1$ for both points on A .

$$\therefore (\pi-\frac{1}{8}-1)\pi a^2=2(4-\pi)(p_1-1)a^2.$$

$\therefore p_1=\frac{6\pi^2-31\pi+48}{12(4-\pi)}$, the probability that the distance is less than the side of the square when one point is within, the other without the circle.

Similarly, $(p'-P)B=2A(p_1-P)$.

$$\therefore P=\frac{2\pi p_1-p'(4-\pi)}{3\pi-4}. \quad P=\frac{15\pi^2-76\pi+104}{3(4-\pi)(3\pi-4)}.$$

MISCELLANEOUS.

176. Proposed by WM. E. HEAL, Coffeyville, Kansas.

In Grassman's *Extensive Algebra*, $e_1e_2=-e_2e_1$. If $e_1=e_2$, $e_1^2=-e_1^2=0$. In quaternions, $ij=-ji$, $i^2j=i.jj=ik=-j$, $i^2=-1$. Reconcile these apparently divergent results.

Solution by G. B. M. ZERR, A. M., Ph. D., Philadelphia, Pa.

i, j, k are unit vectors at right angles to each other. By definition: The effect of any unit vector acting as a multiplier upon another at right angles to it, is the turning of the latter in a positive direction (counter clock wise) in a plane perpendicular to the operator or multiplier through an angle $\frac{1}{2}\pi$. Hence the product or quotient of two unit vectors at right angles is a unit vector perpendicular to their plane. In a positive direction i operating on j produces k , or $ij=k$. Similarly, $jk=i$, $ki=j$. j operating on i in a negative direction produces $-k$. Therefore, $ji=-k$. Similarly, $ik=-j$, $kj=-i$.

The operation of multiplying here is not a numerical product, and hence it is a geometric multiplication, and not an algebraic process.

As the effect of i, j, k as operators is to turn a line from one direction into another which differs from it by 90° , they are called quadrantal versors.

$$\text{Now } ij=k, ik=-j. \therefore i.ij=-j=-1.j=i^2j.$$

$$\therefore i.i=i^2=-1. \text{ Also, } ij=k, ji=-k. \therefore ij=-ji.$$

(See Hardy's *Elements of Quaternions*, pp. 40-48.)